Teaching Plan for B.Sc. (Prog) Chemistry, Semester III (Aug 24 – Nov 24)

Paper Title- Chemical Energetics and Equilibria

(DSC-7, Chemistry-III)

Faculty Name: Dr. Richa Tyagi

S. No.	Month	Week	Topic
1.	Aug-24	1st	Unit 1: Chemical Energetics Recapitulation of Intensive and extensive variables; state and path functions; isolated, closed and open systems, concept of heat, Q, work, W, internal energy, U, and enthalpy, H.
		2nd	*First law* Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities for ideal gas.
		3rd	Joule's experiment, calculations of Q, W, ΔU and ΔH for reversible expansion of ideal gases under isothermal conditions.
		4th	Thermochemistry Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of ionization enthalpy of hydration, enthalpy of formation and enthalpy of combustion
2.	Sept-24	1st	Integral enthalpy of solution, bond dissociation energy and bond enthalpy; Hess's law, Born Haber's cycle (NaCl/ KCl).
		2nd	Second Law : Concept of entropy; statements of the second law of thermodynamics (Kelvin and Clausius). Calculation of entropy change for reversible processes (for ideal gases).
		3rd	Free Energy Functions: Gibbs and Helmholtz energy (Non-PV work and the work function); Free energy change and concept of spontaneity (for ideal gases).
		4th	*Third Law* Statement of third law, qualitative treatment of absolute entropy of molecules (examples of NO, CO), concept of residual entropy
3.	Oct -24	1st	Unit 2: Chemical Equilibrium Criteria of thermodynamic equilibrium. Free energy change in a chemical reaction and equilibrium constant.
		2nd	exergenic and endergenic reactions with examples such conversion of ATP to ADP or vice verca,, Le Chatelier's principle,

			relationship between Kp, Kc and Kx for reactions involving ideal gases.
		3rd	Unit 3: Ionic Equilibria Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ostwald's dilution law, ionization constant and ionic product of water
		4th	Mid-Semester Break
4.	Nov-24	1st	Internal Assessment 1/ Practice Problems
		2nd	Ionization of weak acids and bases, Degree of ionization, pH scale, common ion effect, Buffer solutions, Henderson-Hasselbach equation
		3rd	Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.
		4th	Internal Assessment 2/Practice problem

Syllabus

SEMESTER-III

Course Code: DSC-7 CHEMISTRY - III
Course Title: Chemical Energetics and Equilibria

Total Credits: 04 (Credits: Theory-02, Practical-02)

(Total Lectures: Theory- 30, Practical-60)

Objectives: The objective of this paper is to develop basic understanding of the chemical energetics, laws of thermodynamics and ionic equilibrium. It provides basic understanding of the behaviour of electrolytes and their solutions. The students will also learn about the properties of ideal and real gases and deviation from ideal behaviour.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the laws of thermodynamics, thermochemistry and equilibria.
- Understand concept of pH and its effect on the various physical and chemical properties of the compounds.
- Use the concepts learnt to predict feasibility of chemical reactions and to study the behaviour of reactions in equilibrium.
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Unit 1: Chemical Energetics **Lectures: 16**

Recapitulation of Intensive and extensive variables; state and path functions; isolated, closed and open systems, concept of heat, Q, work, W, internal energy, U, and enthalpy, H.

First law

Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities for ideal gas, Joule's experiment, calculations of Q, W, ΔU and ΔH for reversible expansion of ideal gases under isothermal conditions.

Thermochemistry

Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of ionization enthalpy of hydration, enthalpy of formation and enthalpy of combustion, Integral enthalpy of solution, bond dissociation energy and bond enthalpy; Hess's law, Born Haber's cycle (NaCl/ KCl).

Second Law

Concept of entropy; statements of the second law of thermodynamics (Kelvin and Clausius). Calculation of entropy change for reversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy (Non-PV work and the work function); Free energy change and concept of spontaneity (for ideal gases).

Third Law

Statement of third law, qualitative treatment of absolute entropy of molecules (examples of NO, CO), concept of residual entropy

Unit 2: Chemical Equilibrium **Lectures: 4**

Criteria of thermodynamic equilibrium. Free energy change in a chemical reaction and equilibrium constant, exergenic and endergenic reactions with examples such conversion of ATP to ADP or vice verca,, Le Chatelier's principle, relationship between Kp, Kc and Kx for reactions involving ideal gases.

Unit 3: Ionic Equilibria **Lectures: 10**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ostwald's dilution law, ionization constant and ionic product of water, ionization of weak acids and bases, Degree of ionization, pH scale, common ion effect, Buffer solutions, Henderson-Hasselbach equation. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

Practical: **Credits:02**

(Laboratory periods: 60)

Chemical Energetics:

1. Determination of heat capacity of calorimeter.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of the enthalpy of ionization of acetic acid.
4. Determination of enthalpy of neutralization of acetic acid and ammonium hydroxide using Hess's law.
5. Determination of integral enthalpy of solution (both endothermic and exothermic) of salts.
6. Determination of enthalpy of hydration of Copper sulphate.

Ionic equilibria:

7. Preparation of buffer solutions: (i) Sodium acetate-acetic acid or (ii) Ammonium chloride-ammonium acetate. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
8. Study the effect of addition of HCl/NaOH on pH of the buffer solutions (acetic acid, and sodium acetate).

9. pH metric titration of strong acid with strong base,
10. pH metric titration of weak acid with strong base

References:

Theory:

1. Castellan, G. W. (2004), **Physical Chemistry**, Narosa.
2. Kapoor, K. L. (2015), **A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K. L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6th Edition, McGraw Hill Education.
4. Puri, B. R., Sharma, L. R. and Pathania M. S. (2020), **Principles of Physical Chemistry**, Vishal Publishing Co.

Practical:

1. Khosla, B. D.; Garg, V. C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.
2. Kapoor, K. L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGraw Hill Education.
3. Batra, S. K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry**, Book Age series.

Additional Resources:

1. Mahan, B. H.(2013), **University Chemistry**, Narosa.
2. Barrow, G. M. (2006), **Physical Chemistry**, 5th Edition, McGraw Hill.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Teaching Plan for B.Sc. (Prog) Chemistry, Semester III (Aug 24 – Nov 24)

Paper Title- Green Chemistry

(DSE-5)

Faculty Name: Dr. Richa Tyagi

S. No.	Month	Week	Topic
1.	Aug-24	1st	Introduction: Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.
		2nd	Need of green Chemistry. Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).
		3rd	A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).
		4th	Twelve Principles of Green Chemistry – A brief . Detailed discussion on Principles: Prevention of waste / byproducts, pollution prevention hierarchy.
2.	Sept-24	1st	Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.
		2nd	Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.
		3rd	Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis
		4th	*Green energy and sustainability.* *Real-time analysis for pollution prevention.*
3.	Oct -24	1st	Prevention of chemical accidents, designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl)
		2nd	Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation
		3rd	Unit 3: The following Real-world Cases in green chemistry should be discussed: Surfactants for carbon dioxide. Replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments
		4th	Mid-Semester Break
4.	Nov-24	1st	Internal Assessment 1
		2nd	Designing of environmentally safe marine antifoulant. Rightfit pigment. Synthetic azo pigments to replace toxic organic and inorganic pigments.
		3rd	An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

		4th	Internal Assessment 2

Syllabus

Course Code: DSE-5 CHEMISTRY

Course Title: Green Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives:

Huge rise in environmental pollution, depleting resources, climate change, ozone depletion, heaps and heaps of landfills piling up has forced the society to become more and more environmentally conscious. Future chemists and innovators are compelled to work towards sustainable practices. Green chemistry has arisen from these concerns. It is not a new branch of chemistry but helps to improve the creative and innovative thinking in undergraduate students. Green chemistry is a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. Innovations and applications of green chemistry in education have helped companies to gain environmental benefits as well as to achieve economic and societal goals also. Undergraduate students are the ultimate scientific community of tomorrow. Training them to practice chemistry in the safest way possible is key towards safe working conditions in the laboratories as well as the chemical industry and extends to society in a sustainable future for the planet.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the twelve principles of green chemistry and also build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis

- Appreciate the use of catalyst over stoichiometric reagents
- Learn to use green solvents, renewable feedstock and renewable energy sources for carrying out safer chemistry
- Appreciate the use of green chemistry in problem solving skills and critical thinking to innovate and find solutions to environmental problems.
- Learn to design safer processes, chemicals and products through understanding of inherently safer design (ISD)
- Appreciate the success stories and real-world cases as motivation for them to practice green chemistry

Unit 1: Introduction **Lectures:08**

Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.

• Need of green chemistry

• Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).

• A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).

Unit 2: Twelve Principles of Green Chemistry **Lectures: 12**

The twelve principles of the Green Chemistry with their explanations Special emphasis on the following:

• Prevention of waste / byproducts, pollution prevention hierarchy.

• Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.

• Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.

• Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

• Green energy and sustainability.

• Real-time analysis for pollution prevention.

• Prevention of chemical accidents, designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation

Unit 3: **Lectures: 10**

The following Real-world Cases in green chemistry should be discussed: Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

Practical: **Credits: 02**

(Laboratory periods: 60)

Characterization by melting point, UV-Visible spectroscopy, IR spectroscopy and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, solubility, combustion test, density, viscosity, gel formation at low temperature and IR can be provided).

3. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.

4. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.

5. Mechanochemical solvent free, solid-solid synthesis of azomethine using *p*-toluidine and *o*-vanillin/*p*-vanillin.

6 Microwave-assisted Knoevenagel reaction using anisaldehyde, ethylcyanoacetate and ammonium formate.

7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

8. Photochemical conversion of dimethyl maleate to dimethyl fumarate (*cis-trans* isomerisation)

9. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under

References:

Theory:

1. Anastas, P.T., Warner, J.C. (2014), **Green Chemistry, Theory and Practice**, Oxford University Press.
2. Lancaster, M. (2016), **Green Chemistry: An Introductory Text**, 3rd Edition, RSC Publishing.
3. Cann, M. C., Connely, M.E. (2000), **Real-World cases in Green Chemistry, American Chemical Society**, Washington.
4. Matlack, A.S. (2010), **Introduction to Green Chemistry**, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.

5. Alhuwalia, V.K., Kidwai, M.R. (2005), **New Trends in Green chemistry**, Anamalaya Publishers.
6. Sidhwani, I.T, Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.

Practical:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.